**Case P-10091**

**Applicant: Aktiebolaget Electrolux, Stockholm**

Electronic directing system

## TECHNICAL FIELD

The present invention relates to a procedure and an electronic navigational control system for a self-propelling device, preferably a lawn-mowing robot. The system comprises at least one navigational control station connected to at least one signal generator and a sensing unit arranged at the self-propelling device. The sensing unit senses at least one time and space varying magnetic field propagating in the air medium, at least transmitted via the navigational control station and in turn retransmits at least one signal processed by the sensing unit to at least one driving source that contributes to the movements of the device across a surface.

## TECHNICAL BACKGROUND

The thought of developing fully automatic working tools is old. Such working tools may relate to devices for cutting grass, which from now on will be called a robot. Despite this fact, such products have only in recent years reached the market. One such example is the robotic lawn mower Auto Mower™. It mows a surface by moving across the surface within the area to be worked on. Loops are used to keep the robot within a delimited area. These comprise electrical conductors transmitting signals, which are sensed by a sensing device onboard the robot and thus controlling the movements of the robot from outside. The loops are used, for instance, to mark the boundary, which the robot must not exceed and to make the robot distance itself from the loop.

The sensing device normally consists of at least a receiving device for sensing for instance magnetic fields, a control unit connected to the receiving device to process the received signal and a motor control unit connected to the control unit to control the movements of the robot based on the processed information. When the robot approaches a loop, the system senses a change in magnetic field strength. The control unit processes the information and chooses to direct the robot in a certain direction dependent on which function that is activated.

A disadvantage with the previous loop system is that the robot follows a laid down loop in order to direct the robot towards a certain place, which can be represented by a charging station for the robot's batteries and/or parking place for when the robot is not working. To direct the robot towards this place, one must necessarily put down a navigational control station comprising a big closed loop so that the robot frequently intersects it during its normal movements and thereby has the possibility to start following the loop. A further disadvantage is that present types of navigational control stations normally direct the robot along a path, which is repeated each time the robot is directed. Thereby the robot's wheels will cause wear along the surface area they pass. The present invention has been developed with the intention to remedy these disadvantages.

## SUMMARY OF THE INVENTION

The invention relates to an electronic navigational control system comprising means by which the signal generator sends a current through a navigational control station. The current generates a time and space variable magnetic field, whereby the sensing unit comprises means by which the robot is controlled based on the properties of the sensed magnetic field.

## DESCRIPTION OF DRAWINGS

The invention is described more in detail in conjunction with the preferred embodiments and with reference to the enclosed drawings.

Fig. 1 shows a control system in accordance with the subject invention.

Fig. 2 shows a diagram presenting signals in the control system according to fig. 1.

Fig. 3 shows a self-propelling device for the navigational control system according to fig. 1.

Fig. 4 shows an embodiment of the control station according to fig. 1.

## CLAIMS

1. Method for manoeuvring a self-propelling device (5) by means of an electronic navigational control system comprising at least a navigational control station (3) connected to at least one signal generator (1) and one sensing unit (14, 15, 16) arranged at the self-propelling device (5), whereby the sensing unit (14, 15, 16) at least senses an, in the air-medium propagating, time and space varying magnetic field, transmitted by the navigational control station (3) and in turn retransmits at least one, by the sensing unit (14,15,16) processed signal to at least one drive source that contributes to the device's (5) movements across a surface,

**characterised in**

that the signal generator (1) sends a current through the navigational control system (3), the current generating the time and space varying magnetic field (43,44,52,54), whereby the sensing unit (14,15,16) manoeuvres the device (5) based on the properties of the sensed magnetic field (43,44,52,54).

2. Method according to patent claim 1 **characterised in** that the device (5), when moving mainly outside the range of the navigational control station and sensing a change in the magnetic field (44, 54), manoeuvres itself in relation to the navigational control station (3) so that it by means of one or many manoeuvres will approach, essentially stay at a constant distance from or distance itself from the navigational control station (3), alternatively stop and/or turn.

3. Method according to patent claim 2 **characterised in** that the device (5), when moving in a course direction and senses an unchanged magnetic field strength (44, 54), changes directions 90 degrees, that the device, when moving in a course direction and senses an increased magnetic field strength (44, 54), continues in the same course direction and that the device, when moving in a course direction and senses a decreased magnetic field strength (44, 54), changes course directions 180 degrees.

4. Method according to any of the patent claims 2-3 **characterised in** that the device (5) moves in a course direction that corresponds to that the sensed magnetic field (44, 54) is constant.

5. Method according to any of the patent claims 2-4 **characterised in** that the device (5), when sensing that the magnetic field (44, 54) changes directions (55), continues to move a certain distance in the same direction, then stops and turns until it again detects that the magnetic field (44, 54) changes directions (55), whereupon it moves essentially in the same direction as a line (55), which ties together points where the sensed magnetic field (44, 54) changes directions.

6. Method according to any of the previous patent claims **characterised in** that the sensing unit (14, 15, 16), when sensing the magnetic field (43, 52) within the range of the navigational control station (3), adapts its processing of the sensed magnetic field (43, 52).

7. Method according to any of the previous patent claims **characterised in** that at least one signal generator (1) sends a first current trough the navigational control station (3), whereby the magnetic field (43, 44), generated by the current at a point of time mainly inside the range of the navigational control station (3), has a direction essentially opposed to the direction of the magnetic field (43, 44) at the same point of time mainly outside of the mentioned range.

8. Method according to any of the previous patent claims **characterised in** that at least one signal generator (1) sends a second current trough the navigational control station (3) and the mentioned (1) or another signal generator (1) sends a third current through the navigational control station (3), whereby the magnetic field (43, 44), generated by the second current in a second area mainly within the range of the navigational control station (3), at a point of time has a direction essentially corresponding to the direction (46) of the magnetic field (43, 44) generated by the third current at the same point of time in a third area mainly within the range of the navigational control station (3).

9. Method according to any of the patent claims 1-7 **characterised in** that at least one signal generator (1) sends a second current trough the navigational control station (3) and the mentioned (1) or another signal generator (1) sends a third current through the navigational control station (3), whereby the magnetic field (52, 54), generated by the second current in a second area mainly within the range of the

navigational control station (3), at a point of time has a direction essentially opposite to the direction (50, 51) of the magnetic field (52, 54) generated by the third current at the same point of time in a third area mainly within the range of the navigational control station (3).

10. Method according to any of the patent claims 8-9 **characterised in** that the second current corresponds to the third current.

11. Method according to patent claim 9 **characterised in** that outside and within the range of the navigational control station an undefined area (55) is created that essentially defines two areas, which at a point of time have magnetic fields essentially opposed to each other.

12. Method according to any of the patent claims 8-11 **characterised in** that the direction (46,50,51) of the magnetic fields (43,44,52,54) generated in the second and third areas depend on the properties of the sent currents.

13. Method according to any of the previous patent claims **characterised in** that at least one current in the system constitutes a sinus component.

14. Method according to any of the previous patent claims **characterised in** that at least one current sent in the system most of the time is in a state of rest when it is mainly constant, whereby periodically the state of rest is interrupted by at least one characteristic reference current pulse (7, 9, 11).

15. Method according to patent claim 14 **characterised in** that the sensing unit (14, 15, 16), knowing the properties of the reference pulse (7, 9, 11), adapts the time intervals within which the sensing unit (14, 15, 16) sense magnetic fields.

16. Method according to patent claim 15 **characterised in** that adaptation means that the sensing unit (14,15,16) synchronises the unit's (14,15,16) working frequency in the time domain based on the reference current pulse (7, 9, 11).

17. Method according to any of the patent claims 15-16 **characterised in** that adaptation means that the sensing unit (14,15,16) synchronises the properties of the time intervals in the time domain based on the properties of the reference current pulse (7, 9, 11).

18. Method according to any of the patent claims 14-17 **characterised in** that each signal generator (1) in the navigational control system synchronises its sent current pulses (7,9,11) with the other current pulses (7,9,11) in the system so that no current pulses (7,9,11) coincide at the same time during the same signal period (8).

19. Method according to any of the patent claims 14-18 **characterised in** that each signal generator (1) in the navigational control system synchronises its sent current pulses (7,9,11) with the other current pulses (7,9,11) in the system so that signals, generated in the sensing unit (14,15,16) by one of the sent current pulses (7,9,11), have at least partly tapered off when signals generated by the next sent current pulse (7,9,11) occur.

20. Method according to any of the patent claims 14-19 **characterised in** that a sent current pulse (7,9,11) in each loop (2,3,4,6) has a time function where the current during this function is both positive and negative in relation to the idling current that appears in the loop (2,3,4,6).

21. Method according to any of the patent claims 14-20 **characterised in** that the sensing unit (14,15,16) records positive and negative flanks of the current pulses (7,9,11), whereby the distance in time between these two flanks decides the unit's processing of the detected information.

22. Method according to any of the patent claims 8-12 and any of the patent claims 14-21 **characterised in** that the magnetic field's (43,44,52,54) direction (46,50,51) within the second and the third areas respectively at a point of time depends on the properties and the occurrence of current pulses (7,9,11).

23. Method according to patent claim 22 **characterised in** that when a current pulse N7 (9) occurs, the magnetic field (25) in the second area, at a point of time, shows

a direction (22) essentially opposed to the direction (23) of the magnetic field at the same point of time in the third area and when another current pulse F9 (11) occurs, the magnetic field (25) in the second area, at a point of time, shows a direction (18) essentially corresponding to the direction (18) of the magnetic field in the third area.

24. Electronic navigational control system for a self-propelling device (5), the system comprising at least one navigational control station (3) connected to at least one signal generator (1) and a sensing unit (14,15,16) arranged at the self-propelling device (5), whereby the sensing unit (14,15,16) senses at least one time and space varying and in the air medium propagating magnetic field, at least transmitted via the navigational control station (3), in turn re-transmitting at least one, by the sensing unit (14,15,16) processed, signal to at least one driving source that contributes to the device's movements across an area, **characterised in** that
the system comprises means by which the signal generator (1) sends a current through the navigational control station (3), the current generating the time and space varying magnetic field (43,44,52,54), whereby the sensing unit (14,15,16) comprises means by which the device (5) is manoeuvred based on the properties of the sensed magnetic field (43,44,52,54).

25. Electronic navigational control system according to patent claim 24 **characterised in** that at least one current being sent in the system during the main part of the time is in a state of rest, where it is essentially constant, whereby the state of rest is periodically interrupted by at least one characteristic reference current pulse (7,9,11).

26. Electronic navigational control system according to any of the patent claims 24-25 **characterised in** that the navigational control station (3) comprises a first loop (6) which surrounds a first area.

27. Electronic navigational control system according to any of the patent claims 24-26 **characterised in** that the navigational control station (3) comprises a second and a third loop (4), whereby the second loop (4) surrounds a second area and the third loop (4) surrounds a third area.

28. Electronic navigational control system according to any of the patent claims 24-27

**characterised in** that the respective loop (4,6) extends in one plane.

29. Electronic navigational control system according to patent claim 28 **characterised in** that the plane extends parallel to the ground surface or vertical to the ground surface.

30. Electronic navigational control system according to any of the patent claims 24-29 **characterised in** that at least one loop constitutes an electric conductor this is placed above, in or below the continuous surface across which the device is intended to move.

31. Electronic navigational control system according to any of the patent claims 24-30 **characterised in** that at least one loop constitutes a continuous electric conductor that is wound in more than one turn.

32. Electronic navigational control system according to patent claim 31 **characterised in** that the electric conductor constitutes a fix guide path placed on a carrier.

33. Electronic navigational control system according to any of the previous patent claims **characterised in** that by a self-propelling device (5) is meant an operating robot comprising a operating system for working on the surface across which the robot is moving.

34. Electronic navigational control system according to patent claim 33 **characterised in** that the operating system is controlled based on information received and/or stored for processing by the sensing unit (14,15,16).

35. Electronic navigational control system according to any of the patent claims 33-34 **characterised in** that the robot constitutes a lawn-mowing robot, whereby the operating system constitutes knives which, when moving, cut off the biological material growing on the surface.

36. Electronic navigational control system according to any of the patent claims 33-34 **characterised in** that the robot constitutes a vacuum cleaning robot, whereby the operating system comprises the parts with which a vacuum cleaning robot is

normally equipped for cleaning the surface from dirt, for instance a rotating brush and a suction device.

37. Electronic navigational control system according to any of the patent claims 33-34 **c h a r a c t e r i s e d i n** that the robot constitutes a cleaning robot, whereby the operating system comprises the parts with which a cleaning robot is normally equipped for cleaning the surface from dirt, for instance tools for wet-cleaning.